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Kinetic analysis of canine gait on the effect of failure tendon repair and tendon graft

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ABSTRACT

Kinetic analysis of canine gait has been extensively studied, including normal and abnormal gait. However, no research has looked into how flexor tendon injury and further treatment would affect the walking pattern comparing to the uninjured state. Therefore, this study was aimed to utilize a portable pressure walkway system, which has been commonly used for pedobarographic and kinetic analysis in the veterinary field, to examine the effect of a failed tendon repair and tendon graft reconstruction on canine digit kinetics during gait. 12 mixed breed (mongrel) hound-type female dogs were included in this study and 2nd and 5th digits were chosen to undergo flexor tendon repair and graft surgeries. Kinetic parameters from the surgery leg in stance phase were calculated. From the results, after tendon failure repair, decrease of weight bearing was seen in the affected digits and weight bearing was shifted to the metacarpal pad. After tendon graft reconstruction, weight bearing returned to the affected digits and metacarpal pads. Slight alteration in peak pressure and instant of peak force were identified, but it was estimated to have little influence on post-reconstruction gait. This study could serve as a reference in evaluating canine digit function in flexor tendon injury for future studies.

1. Introduction

The canine model has been a common animal model for flexor tendon related research. Historically measuring functional outcomes, such as digit work of flexion, adhesion formation, tendon gliding ability, healing strength, after tendon repair or reconstruction requires animal sacrifice; it would be ideal if the digit function can be evaluated and monitored in vivo without sacrificing animals. Recent technology by studying the kinematics and pedobarography of canine paw with each individual digit contributions during canine gait may provide a way to evaluate tendon function. Electrogoniometer and 3D motion capture system have been utilized to examine the kinematics both in normal and abnormal canine gait (Adrian et al., 1966; DeCamp et al., 1996; Marsolais et al., 2003). However, it would not be a complete analysis of gait without kinetic outcome, since it gives us an idea of how their body experiences loading. Therefore, force plates were incorporated to analyze the ground reaction force. It was found that the mean force during normal walking of forelimbs was 1.1 times that of body weight and the hind limbs were 0.8 times of body weight (Newton and Nunamaker, 1985). To investigate the methods of differentiating normal from abnormal, a force plate was used to measure contact time, braking, impulsion and ground reaction force in different diseases (Budsberg et al., 1987; Johnston and Budsberg, 1997; Vasseur et al., 1995). For unilateral lameness dogs, walking would result in discomfort and failure to use the injured limb, thus lower braking and impulsion forces (Conzemius et al., 2005; Evans et al., 2003; Schwarz et al., 2017).

Although force plates seem to be ideal for kinetic analysis, it is difficult to differentiate among limbs due to overlap of paw prints especially in smaller breeds with smaller strides (Besancon et al., 2003; Lascelles et al., 2006). In 2003, a group attached a single force sensing resistor to each paw. During dog walking, it was found that 3rd and 5th digital pad (DP) had larger pressure than the metacarpal pad (McP), and McP had larger pressure than 2nd and 4th DP (Marghitu et al., 2003). Since 2004, scientists started to apply portable pressure walkway systems which are composed of multiple force sensing elements to investigating canine gait, leading to better flexibility of locations, detailed pressure distribution of all paws and the capability of collecting multiple prints in one trial. It was found that walking faster would result in larger peak pressure (Burnfield et al., 2004; Schwarz et al., 2017).

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A few studies try to characterize the pressure distribution of the pads in different breeds. In normal forelimbs, for Greyhounds, peak vertical force (PVF) of 2nd DP was lower than McP and other digits. For Labrador Retrievers, 3rd, 4th & 5th DP were larger than 2nd DP but lower than McP. No significant differences were found between left and right forelimbs in both breeds (Besancon et al., 2004). PVF in the forelimbs of German Shepherds showed that McP was larger than other digits (Souza et al., 2013). PVF of normal forelimbs of Pitbulls displayed that McP being the largest followed by 4th, 3rd & 5th and 2nd DP. In addition, overall PVF was 30% lower in Pitbulls with cranial cruciate ligament rupture in the hind limbs compared to the normal. In addition, PVF in affected McP was 70% lower than the control (Souza et al., 2014). On the other hand, instead of comparing PVF among different pads, one study divided the paw print into quadrants and evaluated PVF and the instant of peak force (IPF) in healthy dogs during walking. They found out that in PVF, cranial was larger than caudal and lateral was larger than medial. For IPF, caudal occurred earlier than cranial (Schwarz et al., 2017).

Portable pressure walkway system was considered to be useful in evaluating limb function and loading in canine gait. However, no study has focused on the effect of flexor tendon injury and further tendon graft on canine pedobarography and digit kinetics during gait. Therefore, this study was aimed to encompass a flexor tendon repair failure model followed by tendon graft reconstruction to compare multiple kinetic parameters between affected and non-affected digits in the surgery leg by using a portable pressure walkway system.

2. Materials and methods

This study was approved by Institutional Animal Care and Use Committee. Pain medication was given to the dogs after the surgery to minimize their pain.

2.1. Animals

12 mixed breed (mongrel) hound-type female dogs were included in this study and started at 20 kg of body weight (around 8 months old). All dogs were clinically examined to be healthy and with no signs of injury.

2.2. Data collection

A portable walkway system (emed®-xl, Novel, Munich, Germany) was used to collect pedobarographic and kinetic data. With over 25,000 sensors in the sensing area (1440×440 mm^2), the system offered a resolution of 4 sensors/cm^2 with a sampling frequency of 100 Hz. Data were recorded by a commercial software (emed®-xl/R, Novel, Munich, Germany) and a video was synchronized and recorded in each trial. For each condition, at least 10 successful trials were collected (Fig. 1).

2.3. Study design

All dogs underwent an acclimation period of two weeks, which included a week of quarantine and a week to get used to the environment and the walkway system before the start of the study. 1–3 days before tendon repair surgery, normal gait kinetic data were collected. Next, a failed flexor digitorum profundus (FDP) repair with scar digit model were created in the 2nd and 5th digits in a randomly selected right or left paw. Following anesthesia, the 2nd and 5th FDP tendons were fully lacerated, and repaired with the modified Kessler technique. The surgery paw was wrapped with a sterile dressing in the wrist flexion position. The dogs were housed in a post-operative recovery room until fully recovered from anesthesia, and then dogs were moved to their regular cage with a customized dog jacket. Jackets were used to keep the operative paw non weight-bearing until the incisions heal in about 10–14 days. Then, the jacket was removed and the dogs were allowed full cage

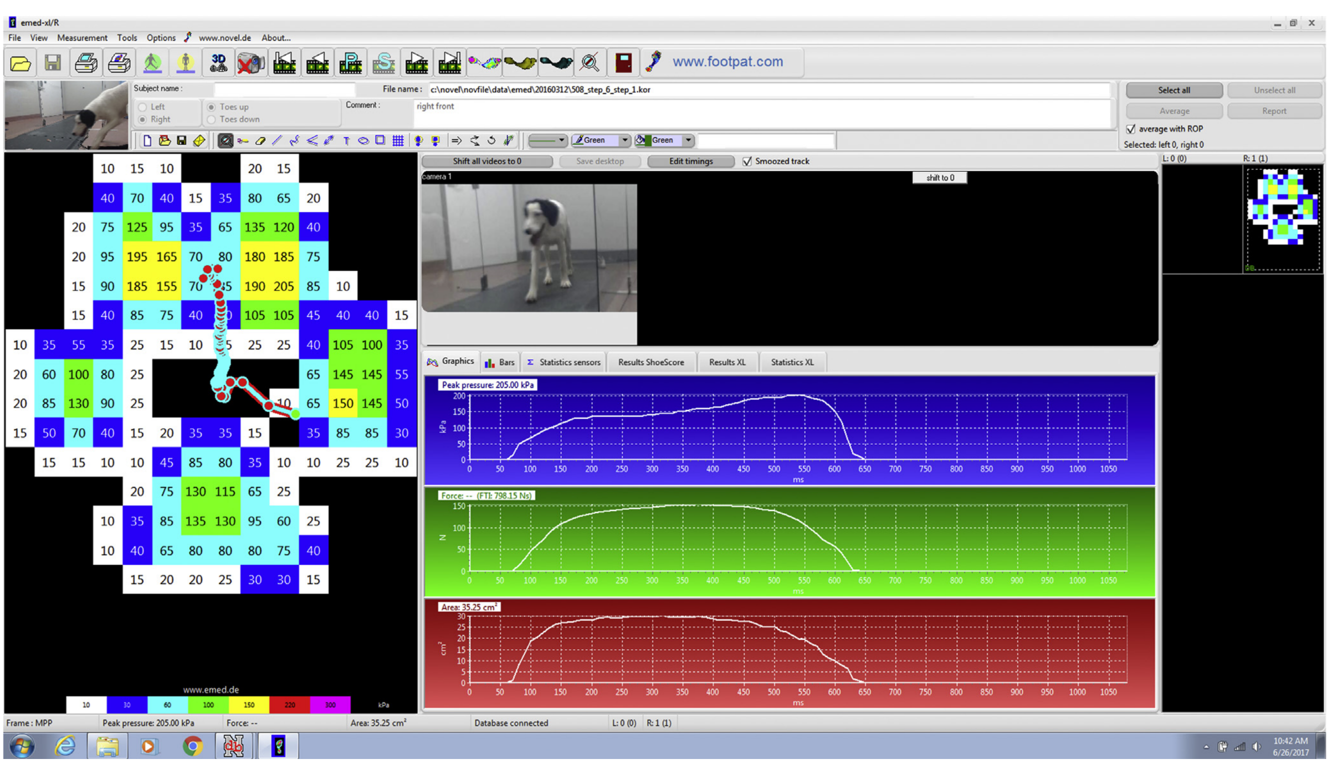

Fig. 1. Software interface for dog gait kinetic data collection with a synchronized video camera.